

LATE-SEASON COLD OUTBREAK, JUNE 24-27, 1958

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1. INTRODUCTION

June was an abnormally cold month for much of the central United States. Elsewhere in this issue O'Connor [1] discusses in detail the monthly circulation and weather. The most severe of a series of cold outbreaks which contributed to the delay of summer weather occurred June 24 to 27. Many long-standing daily temperature records at numerous stations as far south as Texas tumbled to lower levels with this intrusion of Canadian air. Crops were generally retarded and a few small areas where temperatures dropped below freezing suffered actual crop damage. However, the surge occurred so late in the season that strong modifying influences served to temper the onerous effects that cold air earlier would have imposed upon man's activities.

A review of the general synoptic features of the pertinent weather maps for this period, some noteworthy details of frontal reorganization, and some prognostic problems related to the temperature patterns are the main subjects of this article.

2. ANTECEDENT DEVELOPMENTS

Prior to June 24 a cold filling Low on the surface chart meandered in the vicinity of Hudson Bay. North of the Low an extensive area of high pressure was building over Baffin Island, upper Northwest Territories, and the Beaufort Sea. This mass of cold air had a lobe poised over Baffin Island with a ridge westward toward Baker Lake then southwestward toward Montana. The Arctic airmass forming this lobe of high pressure was bounded on the southern edge by an Arctic front moving slowly southward toward Montana and North Dakota. The entire United States east of the Divide except the Gulf States was under the weakening influence of a previous cold surge. The front at the leading edge of the weakened surge became nearly stationary along a line from Georgia to Texas then northwestward parallel to the Divide.

At 500 mb. a semipermanent Low over northern Hudson Bay drifted southwestward through Churchill toward La Pas coming into phase with a short-wave trough moving around a long-wave ridge in Yukon and British Columbia.

The 1000-500-mb. thickness charts showed a cool pool whose central positions coincided with and moved with the 500-mb. Low. Warm air bulged northward from Arizona through Washington to Yukon. Contour gradi-

ents demonstrated a rather sharp discontinuity along the main polar front and a weak Arctic front through British Columbia.

3. EARLY DEVELOPMENTS

At 0000 GMT, June 24 (fig. 1A) the surface chart showed the main polar front along the Gulf Coast to southern Texas then north-northwestward to Montana. The pressure pattern was very weak throughout the United States. A previous cold High had decreased in intensity and all that remained was an unusual lack of pressure gradient. The Arctic front had moved through North Dakota, while an innocuous, inactive-appearing Low drifted into northern Minnesota.

At 500 mb. (fig. 1A), the deep cold Low near La Pas, then in phase with the short wave, was ready to move southeastward into the long-wave position in eastern United States.

The 1000-500-mb. thickness analysis (fig. 1B) displays a well organized thermal wind discontinuity along the main polar front. In the Dakotas and Montana a further increase in thickness gradient at the Arctic front corroborated its existence and intensity. The intensity of fronts is defined by NAWAC in terms of thickness gradient, or thermal wind discontinuity. Strong fronts are defined by discontinuities across the fronts of 75 kt. or more, moderate fronts by 50 to 75 kt., and weak fronts by 25 to 50 kt. in the 1000-500-mb. thermal winds. In addition, the analyst may upgrade or downgrade by one degree of intensity depending on the existence or absence of active weather.

The analysis of thickness departure from monthly normal (fig. 1B) demonstrates the same gradient discontinuities as the thickness. The large magnitude of the negative departure near La Pas revealed the threat of a cold surge into the United States.

By 1200 GMT, June 24 (fig. 2A) the surface chart changed only slightly. The main polar front was still fairly stationary through the Gulf States toward northern Texas then northwestward to Montana. The pressure pattern remained very weak and the Low near Lake Superior continued to fill. The trough in which the Arctic front had been carried was diffused through all of South Dakota, Nebraska, and Kansas. Any thermal discontinuity which had previously existed along this front had disintegrated. Cooling ahead of the front and warming farther to the

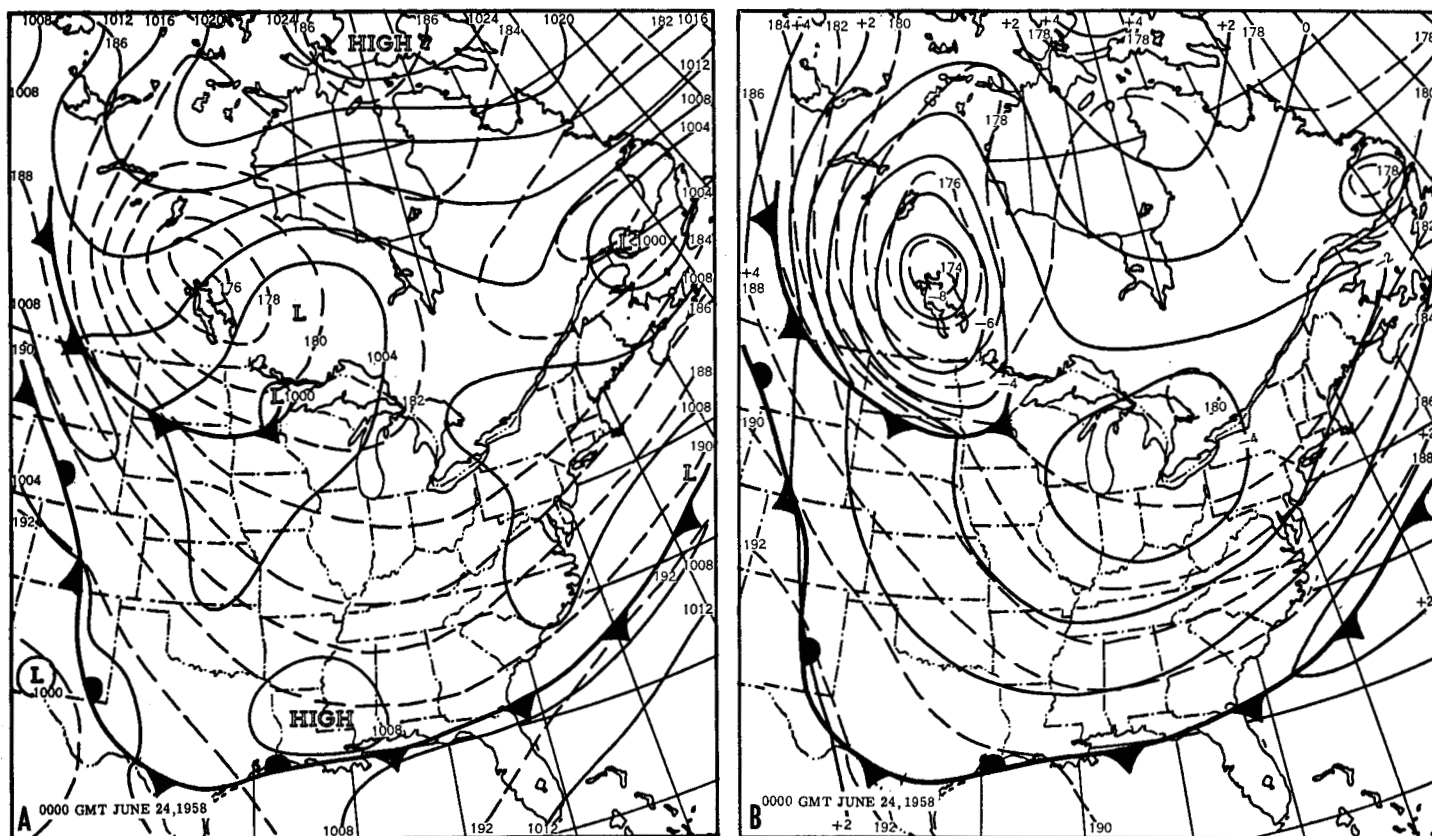


FIGURE 1.—0000 GMT, June 24, 1958. (A) Surface analysis with 500-mb. contours in dashed lines. (B) 1000-500-mb. thickness contours (dashed) and their departure from normal (solid); surface fronts are also shown.

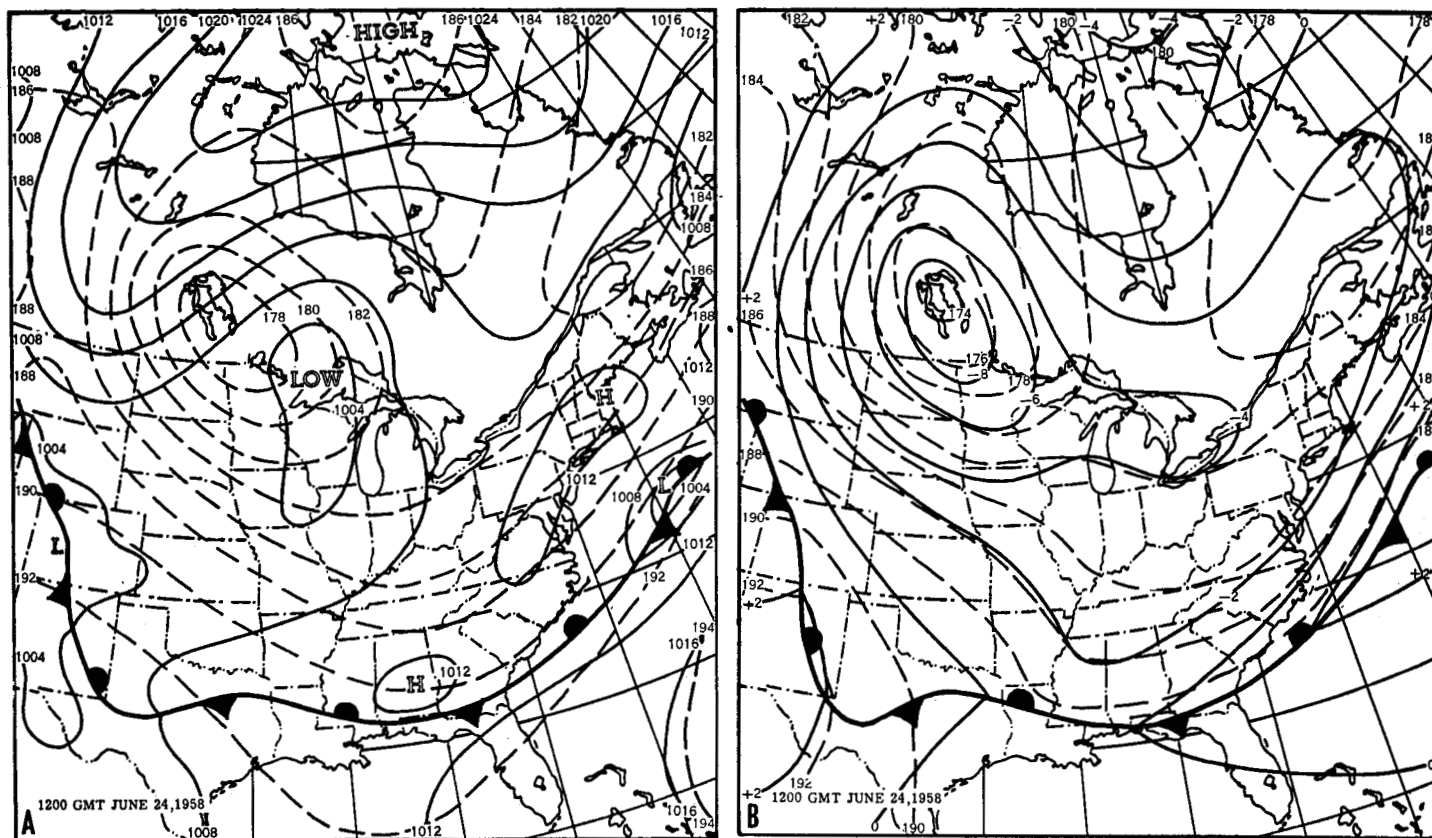


FIGURE 2.—1200 GMT, June 24, 1958. (A) Surface analysis with 500-mb. contours in dashed lines. (B) 1000-500-mb. thickness contours (dashed) and their departure from normal (solid); surface fronts are also shown.

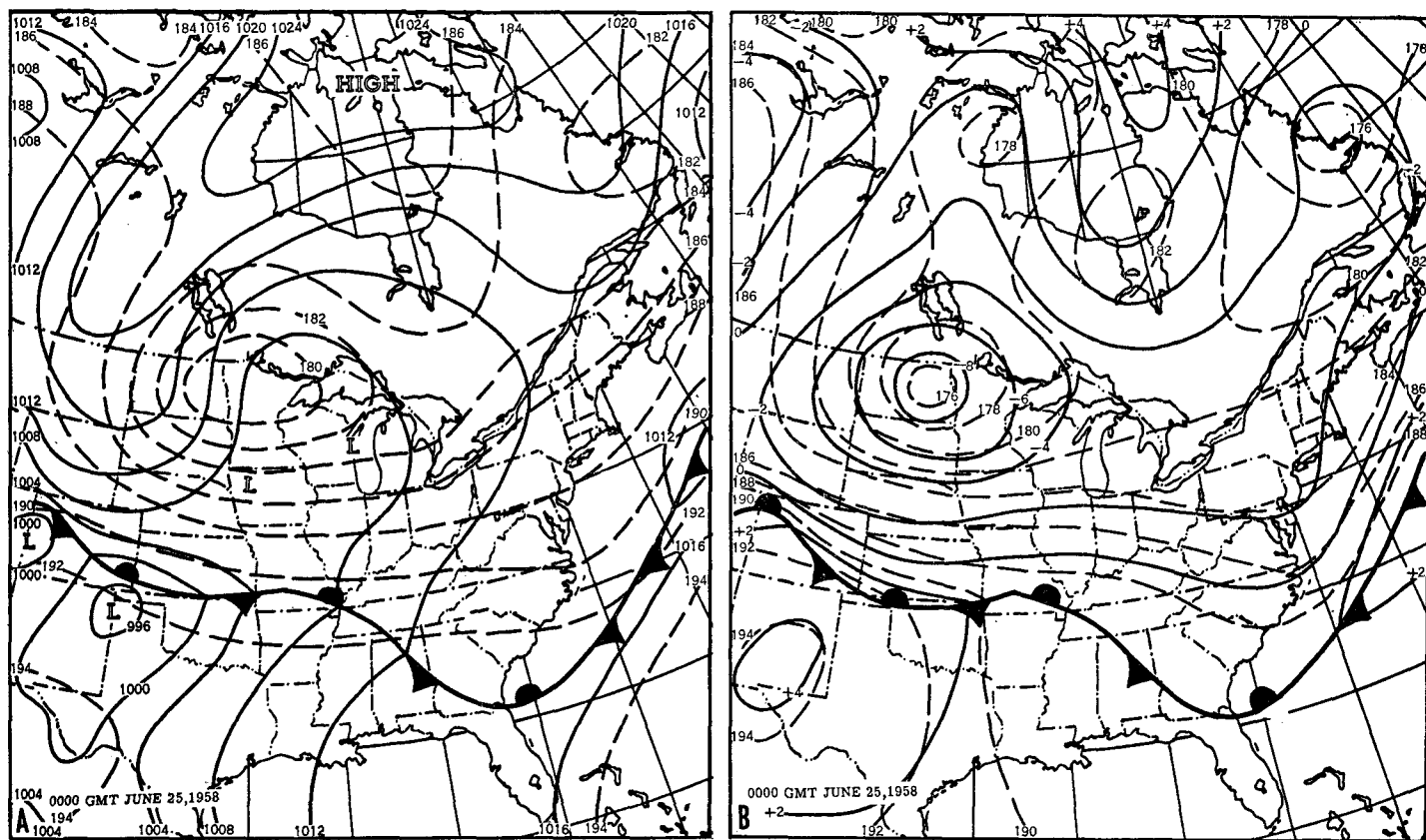


FIGURE 3.—0000 GMT, June 25, 1958. (A) Surface analysis with 500-mb contours in dashed lines. (B) 1000–500-mb. thickness contours (dashed) and their departure from normal (solid); surface fronts are also shown.

south served to increase the thickness gradient ahead of the front. This process left no line of thermal wind discontinuity anywhere north of the portion of the main polar front in Texas.

The thickness chart (fig. 2B) at that time, however, does show a gradually increasing gradient northward from Texas, suggesting that a reorganization of the frontal structure was occurring somewhere near the northern Oklahoma border between the main polar front and the diffuse trough to the north. Along the line where the frontolysed Arctic front had been, all surface pressure tendency discontinuity was gone, and only widely scattered precipitation was observed. At the 850- and 700-mb. levels the isotherm patterns were quite similar to the thickness.

At 500 mb. (fig. 2A) the deep cold Low was moving southeast over Lake Winnipeg. The most striking feature of the circulation was the strong northwest flow from Montana and the Dakotas to the Kentucky, Tennessee, and Alabama area.

An examination of gradients on the thickness departure from normal analysis (fig. 2B) substantiated the lack of definition to any Arctic front in the Dakotas or Nebraska. Still impressive, however, was the large negative anomaly over Lake Winnipeg.

By 0000 GMT, June 25 (fig. 3A), all that remained of the Low then over Wisconsin was a large amorphous area of low pressure with no well defined center. The

advective and in situ warming over northern Texas and Oklahoma caused frontolysis of the polar front in northern Texas. The warming to the south together with the cooling to the north through Kansas, Nebraska, and Colorado caused reorganization of the temperature field into the intensifying frontal zone near the northern Oklahoma border. Afternoon temperatures in northern Texas, New Mexico, and western Colorado, ranged from the middle 90's to over 100° F., while temperatures in the Dakotas were in the 50's. An incipient wave in southern Missouri did not at that time appear very important because a more active Low with better upper-air support was moving into the Texas-Oklahoma Panhandle.

At 500 mb. the principal Low had continued to fill southeastward and was centered over northern Minnesota. An area of height rises centered over Kentucky changed the flow to more westerly over the Central States. The strong short-wave trough had moved south and was observed over North Dakota and Montana.

The thickness patterns (fig. 3B) showed the moderate to strong single frontal organization. The cool pool had moved more southerly than the 500-mb. Low and was centered in northeastern North Dakota.

4. MATURE OUTBREAK

Reintensification of the surface Low in Wisconsin began at 1200 GMT, June 25 (fig. 4A). The weak wave

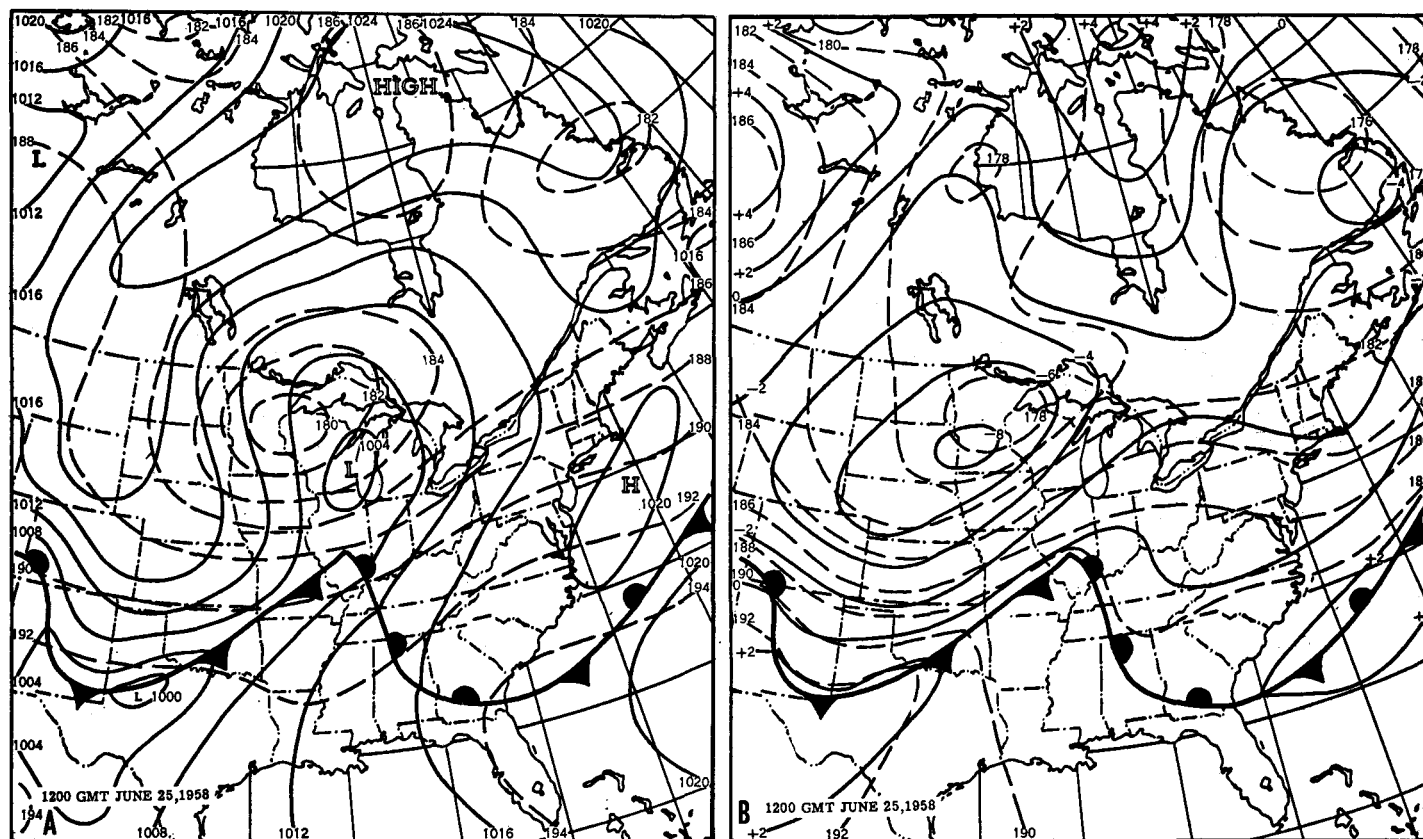


FIGURE 4.—1200 GMT, June 25, 1958. (A) Surface analysis with 500-mb. contours in dashed lines. (B) 1000–500-mb. thickness contours (dashed) and their departure from normal (solid); surface fronts are also shown.

which had been in southern Missouri moved to central Illinois without much increase in circulation but with a marked increase in amplitude. The cold front from the crest of the wave southwestward through eastern Oklahoma to southern New Mexico appeared exceptionally strong even at that early morning hour. Temperatures in the high 70's were present south of the front in Texas while readings in the mid 40's were observed 200 miles to the north in Kansas and Colorado. Considerable precipitation, thunderstorms, strong gusty shifting winds, and marked pressure tendency discontinuities attended the cold frontal passage. The Low in the Panhandle filled as the cold air streamed southward into Nebraska, Kansas, Oklahoma, and northwestern Texas, breaking many temperature records enroute. In figure 5 the stations marked with heavy dots reported in the *Local Climatological Data* various kinds of new temperature records during June 25. Also shown are isotherms of departure of average daily temperature from daily normal. The entire area from the western Great Lakes south to Arkansas, west to Colorado, and north to Montana showed average temperature for the 24-hour period of June 25 to be much below normal.

The similarity of the isotherms of departure from normal temperature (fig. 5) to the contours of thickness departure from normal for 1200 GMT of the same day (fig. 4B) suggests that the latter may be useful in describing the large-scale temperature field. In a case study,

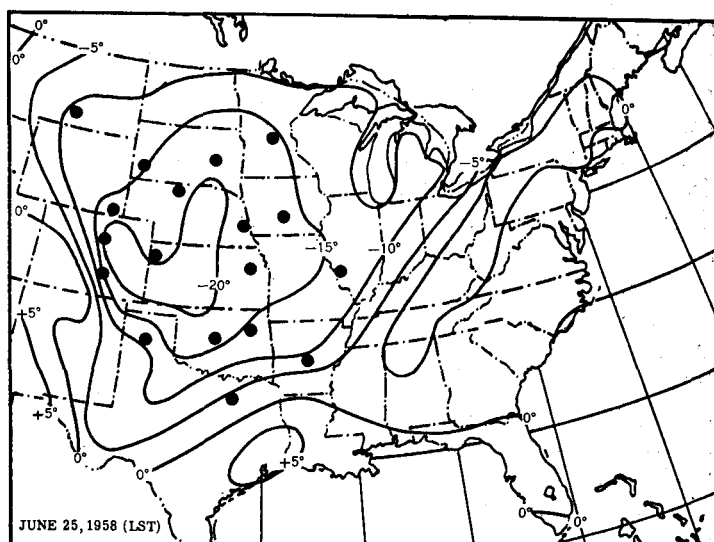


FIGURE 5.—Isotherms of departure of average temperature from normal for June 25, 1958 (local standard time). Heavy black dots indicate stations which reported record-breaking temperatures.

Kibler, Lennahan, and Martin [2] demonstrated some areal relationships between surface temperatures and 1000–500-mb. thickness, especially where a fresh outbreak of cold air was moving into an area. Ellis and Allen [3], Showalter [4], and Boyden [5] have accumulated

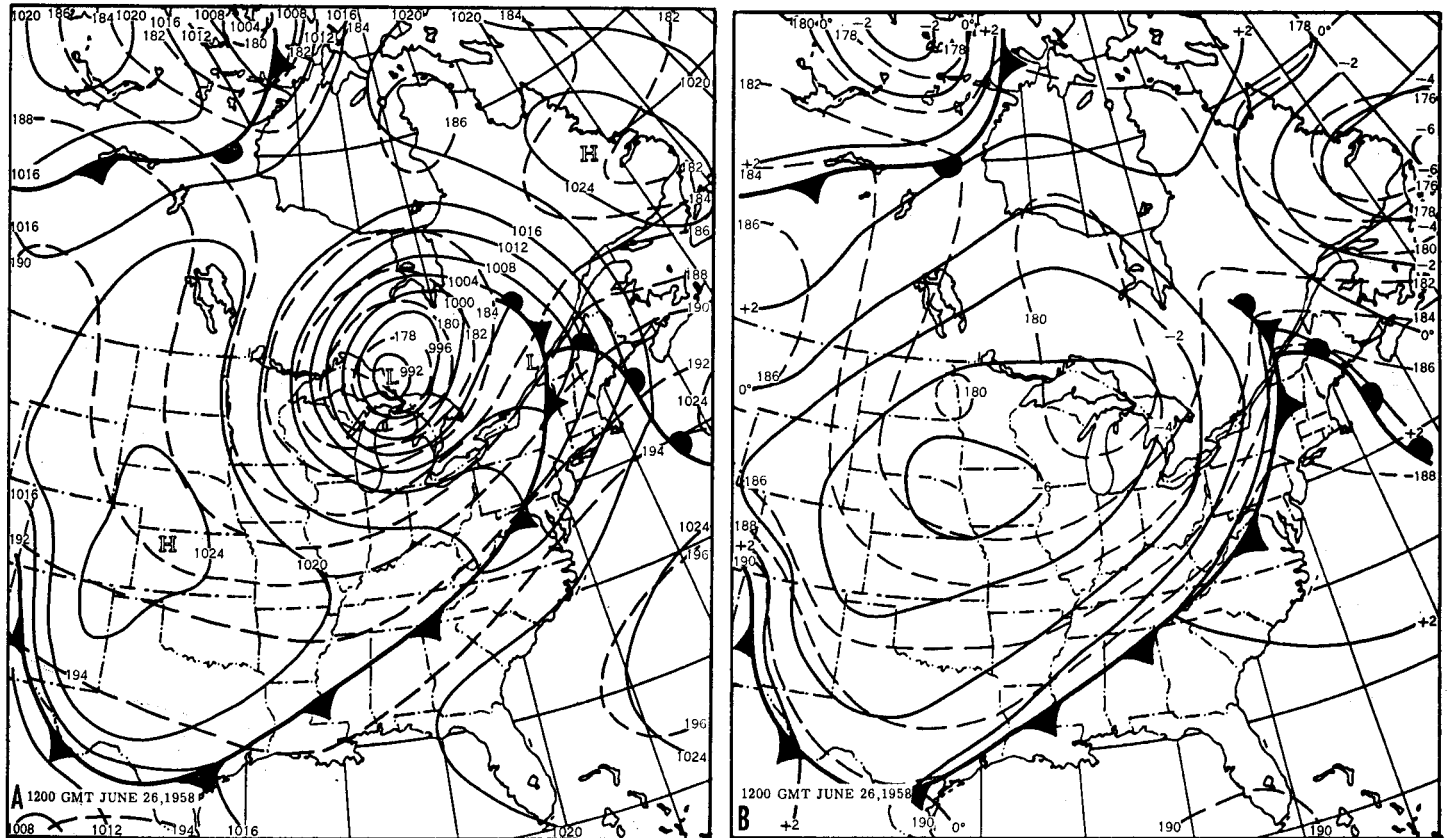


FIGURE 6.—1200 GMT, June 26, 1958. (A) Surface analysis with 500-mb. contours in dashed lines. (B) 1000-500-mb. thickness contours (dashed) and their departure from normal (solid); surface fronts are also shown.

correlations between observed individual surface temperatures and thicknesses. However, the differences between the patterns suggest that other parameters are also necessary to relate the two. Deviations from average lapse rate, cloud cover, presence of precipitation, diurnal changes of temperature, elevation of the station, and local exposures are all important considerations for local temperature forecasting.

At 500 mb. (fig. 4A) the Low was centered near Duluth, Minn., with a trough southwestward toward Wyoming moving around the Low.

The thickness cool pool (fig. 4B) was over central Minnesota. Extremely strong thickness gradients were observed south of the Low extending to the cold front. The large gradient discontinuity along the front confirmed its strong thermal intensity.

By 1200 GMT, June 26 (fig. 6A), the surface Low attained its maximum intensity and depth. The central pressure was down to 990 mb. north of Sault Ste. Marie. The strong northwesterly flow behind the Low had carried cold air as far east as New York and Pennsylvania and as far south as central Texas. Most indications by the surface observations—active thunderstorms, copious precipitation, and large temperature changes—attested to the strong intensity of the front. A portion of the ridge of high pressure which had been in Montana and the Dakotas formed a cold migratory High that moved southeastward into Kansas.

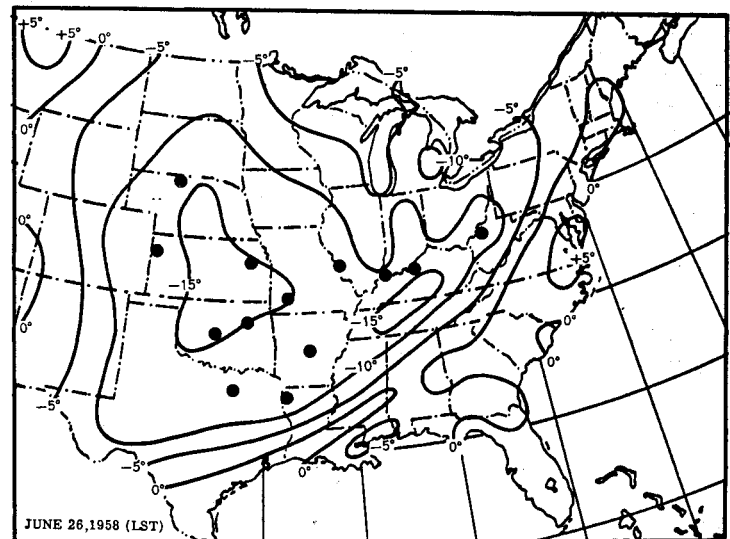


FIGURE 7.—Isotherms of departure of average temperature from normal for June 26, 1958 (local standard time). Heavy black dots indicate stations which reported record-breaking temperatures.

At 500 mb. the Low had deepened and become vertical over the surface Low as the cool pool on the thickness chart lost its definition near the center. The short-wave trough had moved around the Low and was approaching a long-wave position through the Central States.

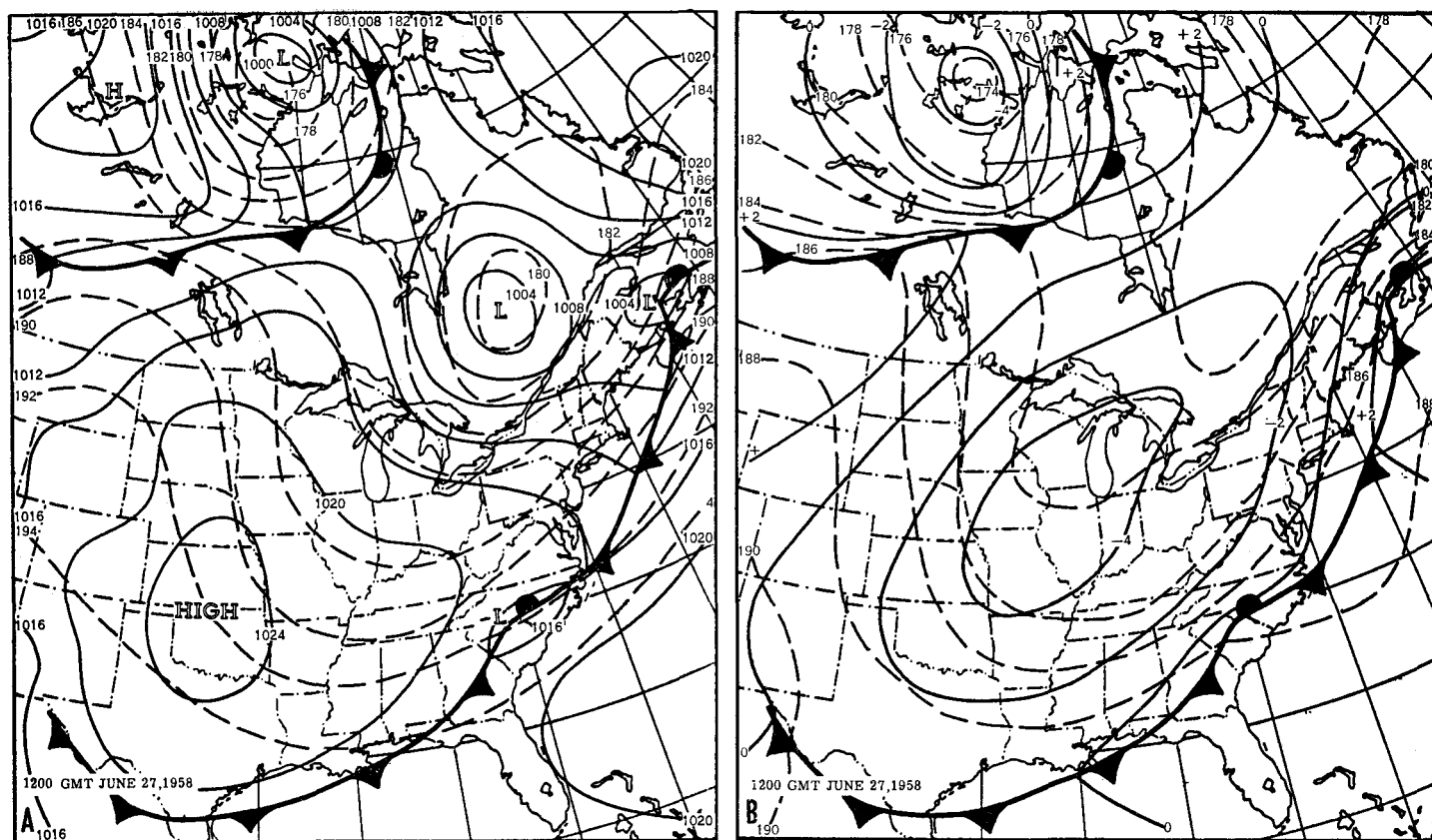


FIGURE 8.—1200 GMT, June 27, 1958. (A) Surface analysis with 500-mb. contours in dashed lines. (B) 1000–500-mb. thickness contours (dashed) and their departure from normal (solid); surface fronts are also shown.

The center of the maximum negative departure from normal of the 1000–500-mb. thickness (fig. 6B) was quite remote from the surface or 500-mb. Low. Both the thickness and the thickness departure from normal still showed a strong gradient discontinuity along the front. However, there was a tendency for the magnitude of thickness departure to decrease. Associated with the decrease was also a tendency for the departure of surface temperatures from normal to lessen (fig. 7). While many stations measured temperatures more than 20° F. below normal on June 25, the largest departures observed on June 26 were about 16° F. The daily records continued to tumble, however, in spite of the modifying forces already in effect.

The surface map at the end of this series, 1200 GMT, June 27 (fig. 8A) shows the filling Low in western Quebec. Northwestern flow had diminished in speed but had extended to the Atlantic coast through New England and southward to Virginia. The high pressure cell became quite flat over Oklahoma and Kansas and the cold airmass continued to modify as it moved southward under the increasing influence of the high angle of the summer sun.

The 500-mb. Low remained nearly vertical with and moved with the surface Low, while the short-wave trough passed through the long-wave position in the eastern United States. The thickness gradients (fig. 8B)

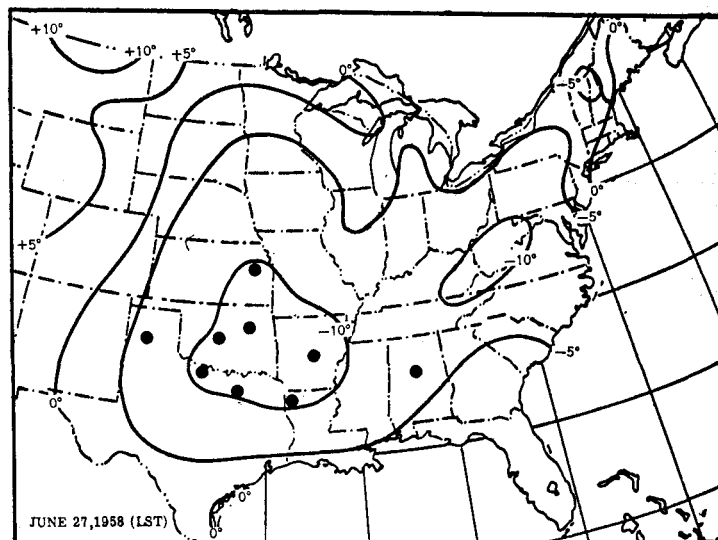


FIGURE 9.—Isotherms of departure of average temperature from normal for June 27, 1958 (local standard time). Heavy black dots indicate stations which reported record-breaking temperatures.

showed further weakening of the frontal intensity and the cool pool no longer had clear identity.

Centered over Illinois there remained a diminishing closed cell of thickness departure which still identified the cold air over the central and eastern portions of the country. The departures of the surface temperatures

(fig. 9) were only about -10° to -12° F.; still many records fell, some for the third consecutive day.

5. SUMMARY

The unusually cold weather during June was the sum of several cold outbreaks, the strongest of which is presented here. The sequence of events in this outbreak was the usual one even though the intensity was extreme. First a mass of cold air formed and cooled in Canada. Then a Low developed rapidly near the central Canadian border. Next the strong northwesterly flow behind the Low forced the cold air into the States in a rapid surge which plunged temperatures to record-breaking levels. Finally the cold airmass moved southward and began to modify.

During the early stages the reorganization of the frontal systems presented an analysis problem which frequently occurs.

An examination of charts of the 1000–500-mb. thickness, thickness departure from normal, surface temperature, and surface temperature departure from normal suggests that there is a relationship between thickness and surface temperature, or perhaps a better relationship between thickness departure from normal and surface temperature departure from normal. This relationship further suggests that a first approximation to a temperature forecast might be found in a thickness forecast. One of the routine charts prepared at NAWAC is a prognostic 1000–500-mb. thickness chart which is not trans-

mitted but is implicit in the 30-hour surface and 36-hour 500-mb. prognostic charts which are transmitted.

Although some research has been done to establish correlations between thickness and surface temperature, further studies including local variation of other influences operating to determine the temperature should be productive.

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